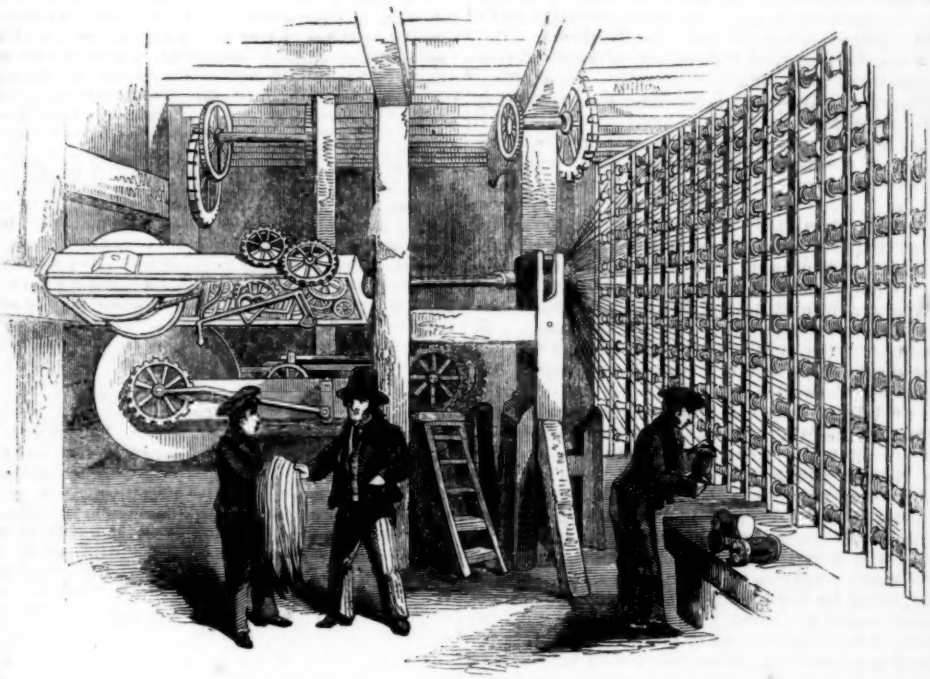
A DAY AT A ROPE AND SAIL-CLOTH FACTORY.



[Strand-registering Machine.—Sir J. Huddart and Co.'s Rope-Works.]

OUR "visit" on the present occasion takes us to the East end of the metropolis, where shipping and the emblems of shipping meet the eye on every side; where the shops exhibit those multifarious commodities necessary for the fitting-up of a ship, or the fitting-out of the "jolly tars," whose castle the ship is to be; where the bustle in the streets is chiefly the bustle connected with seafaring people; and where the very atmosphere seems to tell a similar tale.

The history of a *rope* is a more curious one than many readers or observers would suppose. This invaluable part of a ship's fittings is associated in the minds of some with the idea of a clumsy, dirty, tarry bundle of fibres, roughly twisted together, and coated with something altogether repugnant to the delicate fingers of the West. But we may perhaps be able to show that a large measure of inventive ingenuity has been displayed in the arrangements connected with the construction of a rope, and that—as in many an analogous case—a rough exterior envelops much to merit our attention.

The firm of Sir Joseph Huddart and Co. have liberally permitted us to describe the operations of their manufactory at Limehouse; an establishment presenting unusual points of interest to a visitor, from the circumstance that the manufacture of *ropes* and of *sail-cloth* is here carried on in conjunction. In our notice of Messrs. Green and Wigram's ship-yard, in the volume for 1841, we had occasion to speak of a rigging-house and of a sail-loft; in the former of which the cordage, obtained from the rope-maker, is adapted to the wants of a ship; while in the latter, the canvas, obtained from the weaver, is worked up into the form of sails. To the manufacture of these two commodities, as combined by one firm, the following details relate. But first let us take a bird's-eye view of the buildings and fields and avenues constituting the factory.

Those who are not acquainted with Limehouse beyond the fact that it is situated somewhere in the remote east, may be informed that it is contiguous to the Thames at the north-west extremity of the Isle of Dogs; and even of those who do know the spot, some may perhaps be ignorant that there is a canal extending from the Thames at Limehouse to the River Lea. On the north bank of this canal is situated the factory which the reader is about to visit. The canal was cut some seventy years ago at the expense of the city of London, to form a short communication between the upper course of the river Lea and the Thames at London, by avoiding the tortuous windings of Bow Creek, and of the Thames round the Isle of Dogs. We believe it has not been a very profitable speculation; but with this we have nothing here to do. At the end of a lane a few hundred feet northward of Limehouse Church, and near this canal, we enter, through a pair of folding gates, the premises of the factory.

The first object to be seen is an open plot of ground, bounded on one side by the muddy waters of this almost-deserted canal, and on the other by buildings. A second pair of entrance-gates affords access to the buildings, which consist of three parallel ranges, separated by open courts. The left of these ranges is a long, low, open tile-roofed building, used principally as a rigging-house. In the central and right-hand ranges are the various apartments in which the manu-

facture is carried on, and which are very numerous. Those nearest the entrance are offices and warehouses of different kinds. In one long apartment, full of little floating hempen particles, the hatchelling, or preparation of the hemp, is being carried on. In another is the boiler and other apparatus connected with the tarring of the hempen yarn. In a separate building the barrels of tar are deposited, as a precautionary measure in case of fire. In one room are two beautiful machines, hereafter to be described, for making the earlier forms of a rope without the aid of a rope-walk. In another, iron-floored and fire-proof, is an elaborate machine for making flat-ropes.

But the most novel part of a rope-factory, to a stranger, is the apparently interminable 'walk' or avenue in which ropes are customarily made. These walks far exceed in length the workshops of most other classes of artisans; they are from six to twelve hundred feet in length, and are generally covered with a tiled roof, whether or not they are closed at the sides. At the factory under consideration there are two of these avenues, forming the northern continuations of two of the ranges of building. In one of them, boarded on one side and open on the other, the early process of rope-making is carried on, viz. that in which the hempen fibres are spun into yarns. In the other the ropes are formed from the smaller elements prepared in the spinning-walk; this walk, like the other, has an earthen floor, but it is enclosed on both sides, and has above it another long room where the yarns are prepared for twisting. Here too in the 'laying-walk,' as it is termed (*laying* being the technical term for what we should call the making or twisting of a rope), we may see a little railroad, on which a travelling engine is continually employed in making ropes.

Besides all these buildings, which relate to the rope-manufacture only, there are those connected with the sail-cloth manufacture. First there is a building detached from all others, and provided with boilers, coppers, presses, and other apparatus, where the flaxen yarns are washed and prepared for the weaver. Then there is a large open field, between the rope-walks and the canal, in which the flax-yarns are hung up on poles to dry and bleach; and near this an artificial mound containing a reservoir of water for the use of the whole establishment. Then within doors is a large and busily occupied apartment, filled with machines for winding and preparing the yarns for the weavers. To this succeeds another wherein forty power-looms produce such a deafening clatter as somewhat taxes the ear of one who is unused to such scenes of bustle. In a long avenue we see thirty or forty hand-loom weavers plying the shuttle in the mode which is now so often superseded by machinery, but which is still conveniently adopted under some circumstances. In another room is a calendering-machine, to give the finishing touch to the woven material.

It will thus be seen that the two departments of the establishment occupy a very wide area of ground, and a numerous series of buildings. Let us next endeavour to understand the nature of the processes going on; and first for the

Rope Manufacture.

The material for nearly all our cordage comes from Russia. Some is imported from Manilla, and a small quantity, we believe, from other places; but the great bulk is received from St. Petersburg and the neighbouring parts of the Russian dominions. The quantity which reaches England from that country is immense. In the eight years from 1825 to 1832, there was, on an average, considerably more than a million *poods* imported annually; a *pood* being a Russian weight, of which sixty-three make a ton; or, more familiarly, a pood is about thirty-six pounds English. The value of the hemp imported for our manufactures in 1839 amounted to more than six hundred thousand pounds.

The hemp arrives in England in large bundles, which are separated at the roperies into smaller portions; or rather, this separation is effected in the hold of the vessels, where the bundles, weighing nearly a ton each, are separated into 'heads' or 'layers,' each containing about twelve or fourteen pounds of hemp. The qualities required in good hemp are, that the fibres should be long, fine, and thin, smooth and glossy on the surface, free from fragments of the woody fibre of the hemp-plant, and possessed of considerable strength and toughness.

Before the rope-maker can begin to use the hempen fibres, it is necessary that they should be straight and parallel, free from dirt, and reduced as nearly as may be to an equable thickness. To effect these preparations the hemp is passed through a process which is termed 'heckling,' or 'hackling,' or 'hatchelling.' There seem to be different modes of spelling this word adopted in different factories; for writers on the subject seem to have adopted that particular one which may have been in use at the establishment which they visited; and we shall do the same, for want of a better reason. In one of the upper rooms of the factory a number of men are stationed in a row, with the simple apparatus for hatchelling. On the surface of a small bench before him, each hatcheller has a series of extremely sharp steel spikes, seventy or eighty in number, inserted point upwards, and in parallel order; this is called the hatchel. The workman, taking a 'head' or 'layer' of hemp in his hand, strikes it on the points of the hatchel, and draws it between the spikes; repeating this operation several times with each head.

The hempen fibres are not only straightened by this mode of proceeding, but the thicker ones are split by the sharp points of the wires, and all the loose fragments are made to separate and fall to the ground. Sometimes the hemp is moistened with a little whale-oil, to facilitate its progress through the hatchel; and hatchels of finer or coarser texture, that is, having more or fewer wires in a given space, are used according to the kind of cordage into which the hemp is to be made. The hatchelling-shop presents heaps of hemp, some hatchelled and some not, lying about in different directions; and the air of the room is loaded with dusty particles of hemp, struck out from the heap by the action of the hatchel.

The fibres are straightened and prepared, and the accumulation of them into manufactured cordage commences. It is sometimes asked, "Why should the fibres be twisted; why not bind them together in a straight form?" Their limited length (three or four feet) is the chief reason why this twisting is necessary. If the fibres were of sufficient length, the most effectual mode of obtaining their united strength would be to lay them side by side, fastened together at intervals so as to form a bundle or skein; but as the fibres are so short, it becomes necessary, in order to obtain a rope of greater length than that of the fibres, so to twine them together that the friction between and among them shall offer an effectual resistance to any one of them being drawn out from the mass. The manner in which a hay-band is formed from small blades of hay, will illustrate the strength which this kind of entanglement imparts. But this is not all; the entanglement produced by twisting the fibres not only enables the rope-maker to produce cordage of any desired length, but also, by making the rope hard and compact, increases its durability, and enables it in a great measure to resist the penetration of water.

The fibres, then, are twisted round one another to

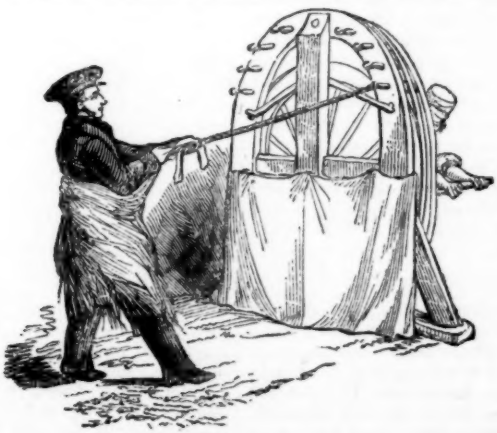
form a rope; but here a curious circumstance presents itself for notice. We never see a bundle of fibres simply formed into one twist; for a rope appears to present some twists in a left-handed direction, and others in a right; and also it appears to be made up of smaller ropes. Let us analyse a 'rope's end,' and see how it is built up. We have here a representation of a small piece of cablet (a nautical name for rope formed in the same manner as, although much smaller than, a cable), which is so dissected at one end as to show the component parts. In the first place we have the cablet itself *a*, presenting the appearance with which most persons are familiar who have ever been on board a ship. By applying a little force to this, we can untwist it, and it then presents to view three smaller ropes, such as *b*, the powerful aggregation of which had formed the cablet. Each of these is known

[Analysis of a Rope.]

technically as a 'hawser-laid' or 'shroud-laid' rope, meaning thereby a rope formed in the same manner as a hawser or a shroud rope. Selecting one of these three, and applying a force to untwist it, we find that it is formed of three smaller ropes, such as *c*, which are called in the roperies 'strands;' so that there are nine of these strands in the cablet. Pursuing our analysis still further, by untwisting one of the strands, we find that it is composed of a considerable number of small strings, such as *d*, all about equal in thickness; these are called 'yarns;' and if we untwist one of the yarns, we arrive finally at the hempen fibres themselves, represented at *e*.

It thus appears, that instead of twisting many hundreds or thousands of hempen fibres one round another, there are successive groups formed, each one augmenting the thickness of the rope previously produced; thus many *fibres* are spun into a *yarn*, many yarns into a *strand*, three strands into a *rope*, and three of these latter into a *cable* or *cablet*. Now for the reason of this. If a cable were formed at once of the individual yarns, twisted one round another, the outer layer would be necessarily exposed to more stress than the internal yarns, since the latter lie at less distances from the centre of the rope. When twisted together the outer yarns would form a spiral of a number of turns round the included yarns, being thereby much shortened; whilst the inner yarns would take only the same number of turns round a reduced axis, being thereby less shortened than the former; from whence it would follow that the outer yarns only would be in full tension, while those within would be more or less coiled up according to their proximity to the centre of the rope. The ultimate result would be, that the outer yarns would break long before the inner ones had borne their fair share of the strain to which the rope might be exposed. It is probable that in the primitive times of rope-making this rude method was adopted, and that it was gradually abandoned when the makers found that the yarns would bear more equally by building up the rope as it were piecemeal, and giving to each successive accumulation a twist in a direction contrary to that of its component parts.

The rope, then, is made at several successive stages, the first of which is the 'spinning' into yarn. At one end of the long rope-walk is a wheel, three or four feet in diameter, round which a band passes in such a manner as to give rotation to a number of small hooks or whirls disposed round a semicircular frame above the wheel. These hooks are from eight to twelve in number, and are each adapted for the spinning of one yarn. The spinners advance, generally in sets of four at a time, to the wheel, and commence that operation which, however simple, is often inexplicable to a by-stander, and which we have here sketched. Each spinner



[Spinning.]

has a bundle of hatchelled hemp round his waist, the double, or 'bight,' being in front, and the ends crossing each other behind. With his left hand he draws out a few fibres, and fastens them on one of the hooks. With

his right, which holds a piece of thick woollen cloth, he grasps these fibres. A man then turns the wheel, and the spinner walks backwards. It is curious to observe the effect of this double movement. The man draws out more and more fibres from his bundle as he recedes; and the twist which is given to these by the rotation of the hook makes each length of fibre entangle among or cling to those previously drawn out, while the pressure of the right hand regulates the hardness or closeness of the twist. A little consideration will show that the rate at which the spinner walks backwards, the rapidity with which the hook rotates, and the number of fibres drawn out by each movement of the left hand, are all concerned in determining the thickness of the yarn produced. The men by long practice are enabled so to proportion their movements as to produce any given length of yarn from a given weight of hemp.

In this way the spinners continue to work for hours together, walking backwards while they are spinning the yarn, and forward while the yarn is being wound on a reel. Along the whole length of the 'walk' there are at intervals transverse beams overhead, into which hooks are driven; and on these hooks the yarns are suspended when it is necessary to prevent them from trailing on the ground. Each spinner can make about a thousand feet of yarn in twelve minutes. The number of fibres forming each yarn is never reckoned among the rope-makers' calculations; but the yarn is estimated by the *weight* of hemp contained in a given length: thus, a rope three inches in circumference being taken as a standard, and this divided into three strands, the yarns are numbered 18, 20, 25, 30, or 40, according to the number required to form one of these strands, and each of these has a definite weight for a given length. For a three-inch rope, of which each strand is to contain twenty yarns, one hundred and sixty fathoms (nine hundred and sixty feet) of the yarn must weigh three pounds and a half. All these are matters which the fingers of the spinner regulate almost intuitively; he does not stop to work out 'multiplication sums,' but produces a 'No. 20' or a 'No. 25' yarn by manipulative adjustments, of which he himself could probably give very little explanation.

We may mention here that nearly all the spinning and twisting concerned in rope-making are or have been more or less effected by machinery in different factories; but in principle the effect is precisely the same whether the hooks be made to rotate by a hand-winch or by a steam-engine applied to a larger apparatus; and we have therefore spoken of the spinning in its simplest and most easily understood form. When a 'spinning-walk' is in full operation, there are twelve spinners at different parts of its length, in three groups, each group being distant three or four hundred feet from the next adjoining, and all the twelve hooks or whirls of the wheel being engaged at once. As the yarns are twisted, they are wound in large bundles upon reels, each reel containing about two hundred and fifty pounds of yarn.

We must next speak of a distinction between 'white-rope' and 'tarred-rope.' When a rope is to be used in the open air, but under cover, it is left in the 'white' state; that is, it is not coated with tar or any other substance. But when it is exposed to the action of water, a coating of some composition is found necessary to enable the hemp to resist the rotting influence of the water, and tar is the substance almost universally used for this purpose. As regards actual strength, an untarred rope is the stronger of the two; but this is more than counterbalanced by the action of water on the hempen fibre. Propositions have at several times been made to substitute for tar some other composition; but we have here only to speak of the method actually employed.

The hemp is tarred (if tarred at all) after it has been spun into yarn, but before the yarns are twisted into strands. The reels of yarn are first 'warped' into a 'haul,' that is, the yarns are unwound from the reel, stretched out straight and parallel, and assembled together in a large group called a 'haul.' This haul frequently consists of between three and four hundred yarns, each a hundred yards in length; and in this state the hemp is tarred. In one of the buildings of the factory is a huge copper for containing melted tar. The haul dips into the tar (which is heated to a temperature found to be the best for penetrating to the heart of every yarn), and is then dragged through a grip or gauge, which compresses the yarns so much as to force the tar into every part of the haul, and at the same time squeeze out the superfluous portion. By the aid of a capstan the haul is drawn gradually forward, until the whole has passed through the tar-kettle.

The tarred haul then passes into an upper building of the factory, called the 'winding-loft,' where it is wound, by the aid of a simple but ingenious machine, upon bobbins about a foot high, each bobbin being made to contain about twenty pounds of yarn.

The state to which we have now traced our rope is that of a yarn, say one-sixth or one-eighth of an inch in diameter, rough, somewhat uneven, and of a brown colour. This yarn we have next to trace into the form of a 'strand.' As the thickness of yarns is classified according to the number of them required for a three-inch rope, so does the number of yarns combined to form a strand depend altogether on the thickness of rope to be formed. It is this which forms the chief point of difference between different ropes, for the yarns do not differ very greatly in thickness. In the piece of cablet of which we have given a sketch there are only seven or eight yarns in a strand: in a cable twelve inches in circumference there are eighty yarns to a strand; and in the very largest rope-cables ever used in the navy, three hundred and sixty. But whatever be the number, whether as few as seven or as many as three hundred and sixty, they are all twisted uniformly one around another to form a strand. It may be convenient to bear in mind that when the size of a rope is mentioned in inches, it invariably relates to the *circumference*, and not to the *diameter*: thus a first-rate cable of twenty-five inches is about eight inches in diameter, the larger measurement referring to the circumference.

Here we have to speak of one of the improvements effected by the late Capt. Huddart. When the number of yarns in a strand is very great, a difficulty occurs to which we have before alluded, viz. the unequal strain upon the external and internal parts. About the beginning of the present century Capt. Huddart showed that, in order to equalise the strain, the outer yarns of every strand ought to be somewhat longer than the inner, to compensate for the greater circumference round which they have to turn. He had previously been an officer in the East India Company's service; but he embarked in the undertaking of rope-making chiefly with a view to put in practice certain improvements which his inventive ingenuity had devised; and he thus laid the foundation of the eminent firm which bears his name.

Without detailing the various steps by which improvements were introduced, we will at once proceed to the beautiful machine represented in our frontispiece. In a skeleton frame, concave towards the centre of the room, are a great number of 'bobbins,' each loaded with yarn ready for being formed into a strand, and each being poised on a pivot so as to rotate

with facility. The ends of all these yarns, which may be twenty, fifty, eighty, in number, are made to pass through an equal number of small holes in a convex plate attached to the central machine, and then combined into one close group. This group next passes through a tube, whose diameter is such as to compress the yarns into close contact, and lastly is wound on a large reel attached to the machine. Meanwhile the twist is given to the strand by a remarkable arrangement. The whole of the mechanism, from the tube to the reel, rotates round an horizontal axis; and, in so doing, imparts a twist to the strand which is passing round the various wheels. The different adjustments are very beautiful. In the first place each bobbin, rotating separately on its axis, gives off just as much yarn as the strand requires; so that all become equally strained, by the outer yarns being somewhat longer than the inner. Then the arrangement of the holes in the plate, and of the tube, bring all the yarns to their proper position in the strand: and lastly, by changing the wheels in the machine, the strand becomes more or less hard, by twisting at a more or less acute angle. If the strand be drawn more swiftly through while the machine is revolving with a given velocity, the intensity or closeness of the twist is diminished; if less swiftly, then the twist is increased. The system for attaining any required intensity of twist is called the 'register,' in relation to the means for determining the exact degree of twist in the strand; and hence the whole process has come to be termed, in the technical language of the factory, *registering*.

A registered strand, or the strand produced by twisting the yarns together by this machine, is a smooth, uniform piece of cordage, all the yarns twisting round in one direction, and all contributing equally to the strength of the whole. Its thickness varies according to the purpose for which it is intended. Thus a strand for a twelve-inch cable contains eighty yarns, and is about an inch in diameter; while that for a smaller rope would be proportionally thinner. The nature of this machine is such that it can produce an endless strand; for if new bobbins are placed on the frame as fast as the old ones are exhausted, and if the strand is removed from the reel as fast as made, the machine, worked as it is by a steam-engine, may continuously add to the length of the strand.

There is another registering-machine of a larger size in the same building, for producing strands of greater diameter. There is also, in that part of the factory called the 'laying-walk,' a curious travelling-engine, which twists the strands of small diameter. At one end of this walk is a bobbin-frame, similar in principle to the one before noticed, and from this the several yarns proceed through a perforated plate, as in the other instance; but instead of being twisted by a machine which revolves on its own axis, the yarns are fastened to revolving hooks attached to a travelling-carriage, which moves in a railway farther and farther from the bobbin-frame as the strand becomes more and more lengthened. The railway extends probably a thousand feet in length; and the machine, which is about a yard long, travels from end to end of this railway in about half an hour, setting in rotation the hooks to which the yarns are attached.

It is not easy for a stranger at first to understand the technicalities of a ropery, for though the word 'twisting' would express the whole succession of steps, yet we hear of 'spinning' when the fibres are twisted into a yarn, 'registering' when the yarns are twisted into a strand, and 'laying' when the strands are twisted into a rope. We must accustom ourselves to the last of these terms in attending to the process next to be described.

In the 'laying-walk' a revolving wheel, placed near one end, is provided with hooks whereon the three strands to form a rope are fixed (four being sometimes the number, but generally three). These hooks are made to rotate by any of the usual methods, such as turning a hand-winch connected with a wheel which acts on all the hooks, or bringing steam-power into action; both these methods being employed at the factory which is engaging our attention. At the other end of the walk all the strands are fastened to one hook, which revolves in an opposite direction to the others; and it is easy to conceive that this double movement would twist all the three strands round each other. But it is equally easy to see that this twisting would be very unequal, unless other appendages be employed; since the twist would be more close or hard near the ends than at the middle.

The annexed cut represents the singular contrivance for equalizing the hardness of the twist or 'lay.' A

['Laying, or making a Rope.]

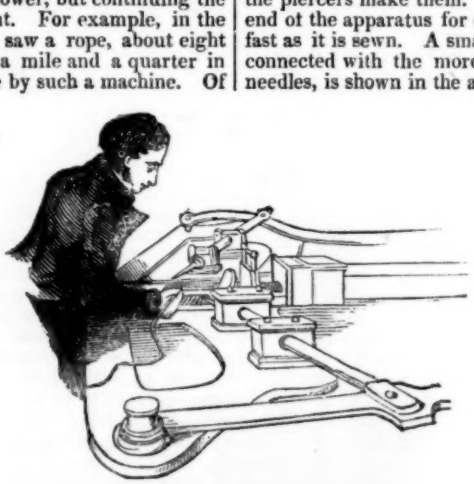
conical or rather beehive-shaped piece of wood, called a 'top,' is inserted between the three strands, grooves being cut in the surface of the top for their reception. This top, thus placed, prevents the strands from twisting, except in the direction of its smaller end; while a man, stationed immediately behind, compresses the rope by a simple piece of apparatus, and causes the twist to become hard and firm. The top, as the rope closes behind it, is slowly urged on from one end to the other; if small, it is managed by a 'top-man,' but if large, it is supported on a carriage, as in our cut. No difference exists in the making of a larger or a

smaller rope, so far as principle is concerned; the three strands are twisted round each other in the same manner, by apparatus more or less powerful, according to the size of the rope. As it is a natural consequence of the twisting process, that the rope should gradually shorten as it is formed, provision is made for this shortening in the arrangement of the apparatus. The wheel to which the three strands are fixed, on three separate hooks, is a fixture at one end of the 'walk;' but the other end of the strands is fastened to a moveable sledge, which is so weighted as to travel gradually up the walk, just as fast as the rope diminishes in length.

A rope thus formed from three strands is the kind which most commonly meets our notice on land, and is technically known as 'hawser-rope,' or 'shroud-rope.' From three such ropes a cable, or cablet, is formed in precisely the same manner; the three being fixed to three revolving hooks at one end, and one at the other; and a travelling 'top' being used to regulate and harden the twist. It may be well to remark, that ropes as ordinarily formed, that is, with three strands, do not require a 'heart,' or central strand, because the angles formed by the union of the three cylindrical strands are such that the pressure, in the operation of laying or closing the rope, causes the strands to fill up the central space completely; but when the number of strands exceeds three, a 'heart' is essential to keep them equidistant from the axis of the rope, and to fill up the vacancy that would otherwise be left by their not meeting in the centre. The heart however does not add proportionate strength to the rope, since its fibres, being straighter than those of the outer strands, yield in a different degree.

All arrangements, such as the above, produce ropes of a definite length, viz. the length of the rope-walk. But some machines have been constructed for 'laying' endless ropes, that is, not only effecting all this twisting and hardening by steam-power, but continuing the process to any required extent. For example, in the warehouse of the factory we saw a rope, about eight inches in circumference, and a mile and a quarter in length, which had been made by such a machine. Of these machines a magnificent series, constructed by the late Captain Huddart, now occupy a place in Her Majesty's Dock-yard at Deptford; they are for 'laying' cables of the largest dimensions, and have attracted much attention from engineers. It is worthy of notice, however, in connection with these details, that iron chain-cables are now superseding hempen cables of large size; the latter being at the present day seldom made more than twelve inches in circumference, except for Her Majesty's Navy.

One of the upper buildings of the factory contains a powerful and curious machine for making *flat ropes*. These are ropes useful in mining operations, and consist of three or four well-made round ropes stitched together side by side. The operation of making these is simply a gigantic kind of thread-and-needle work; yet the force required renders the employment of a complicated machine necessary. Supposing four round ropes are to form the flat rope, four reels are so placed that the ropes can unwind from them with facility, and pass side by side through a steam-heated box, where the tar becomes a little softened, and the ropes more easily worked. They next pass through a groove or a recess closed in tightly at top, bottom, and sides, except holes at the sides to admit the needles. A piercer, formed of a sharp-pointed rod of steel, probably a foot long and half an inch thick, is then forced entirely through the whole of the four ropes, by a leverage of enormous power; and a man immediately afterwards passes a needle and thread through the whole. When we say that this thread is a hempen-yarn sometimes half an inch in thickness, it will be readily conceived that the hole for its reception is a tolerably large one, and that no little force is required in drawing the thread tight. Two steel piercers are employed in succession, one on either edge of the rope, making diagonal holes through the four ropes; and two men, provided with needles and thread, pass the latter through the holes as fast as the piercers make them. There is mechanism at one end of the apparatus for drawing the rope forwards as fast as it is sewn. A small part of the arrangement, connected with the more immediate insertion of the needles, is shown in the adjoining cut.



[Flat-rope Making.]

The difference between the varieties of cordage, called *twine, cord, string, rope*, &c., is chiefly matter of detail; the actual formation by twisting being nearly the same in all. The finer and lighter kinds of twine are made of flax, others of fine hemp more carefully heckled than that for larger rope. The spinning here takes the place of subsequent processes in the rope-manufacture, for there is no 'registering' or 'laying' in fine twine. Generally speaking, the twine and small cord manufacture is, we believe, carried on only to a limited extent by the firms which make the large ropes for shipping; and it presents no marked features calling for our attention here.

Let us next take a rapid glance at the

SAIL-CLOTH MANUFACTURE.

This department so far bears an analogy to that of the rope-manufacture, that vegetable fibres constitute the material of manufacture in both, and that these fibres are spun into a thread or yarn at an early stage

in each manufacture. But beyond this point analogy ceases. Sail-cloth is the stoutest, the strongest, and the most durable of all varieties of *flax* fabrics. It is in fact a *linen*, so far as linen is a generic name for woven flax; but *canvas* is a more usual name. The powerful strain which the sails of a large ship are required to bear, renders necessary the employment of well-spun flax and well-woven yarns in the production of the cloth from whence they are made. In the Royal Dock-yards the quality of the sail-cloth is closely attended to; and there is equal attention paid to the subject in the East India Company's shipping. In the merchant service generally, the quality is more or less excellent, according to circumstances; and any one who has glanced at the shipping below London Bridge will not fail to have remarked the strange medley of sails which the lower classes of vessels display.

Why it is that sails are not made of *broad* canvas, of a width somewhat analogous to that now employed by the floor-cloth manufacturers, we do not know; but the fact is that sail-cloth is woven only to a width of about two feet; so that a large number of joins is required for a large sail. It is not improbable that a greater waste of material would occur in cutting a sail from broad canvas than from that of narrower width, in consequence of the curved and inclined edges of the sails. Be that as it may, the custom seems to have been of long standing and general application, and as such we must view it.

The flax for making sail-cloth is not spun into yarn in London; this process is effected in the flax-manufacturing districts of Scotland, from whence the yarn is purchased for the London market. The yarn comes to the factory in large bundles, made up of smaller hanks or skeins. It is of a light-brownish colour, and has to undergo a washing and partial bleaching process before it is used for sail-cloth. For this purpose the bundles are taken to the 'bucking-house,' a building provided with various coppers, boilers, and large steeping-vessels. The yarn is thrown, in the first place, into hot alkaline liquor, composed of potash or pearlash in hot water, and there steeped for some time. From thence it is removed to a receptacle called a 'splash-mill,' somewhat resembling a fulling-mill, where it is beaten and worked about to free it from impurities. To this succeeds a thorough rinsing or washing in a stream of running water. The water thus imbibed by the yarn is next squeezed out by an hydraulic press; the yarn being put into a box, and pressure being there exerted on it, by which almost every semblance of moisture is expelled. But all this is merely preparatory; for the yarn is next subjected to a five-hours' boiling process, in a copper containing alkaline liquor. All these operations are, as may be supposed, very wet and not very cleanly; so that the 'bucking-house' is the least attractive part of the factory.

When all that alkaline liquor can remove is thus removed from the hemp, the skeins or hanks are hung out in the open air for several days to dry, and—in the act of drying—to bleach. The 'bleach-field,' as viewed from the summit of the reservoir, has a singular appearance. A series of upright posts support two rows, an upper and a lower, of horizontal poles, on each of which the hanks are hung. As each of these poles runs out to a considerable extent, and as there are twenty or thirty of these frames or scaffolds ranged parallel one to another, the whole field looks like one mass of flax, extending from the ground to a height of about six feet. Here the flax remains about a week, exposed to the air, the action of which, combined with the previous washing and boiling, gives a considerable degree of whiteness to the flax. Near the bleach-field is a drying-shed, in which the flax is hung up in certain states of the weather. There is also a 'stove-room,' in which the flax can be exposed to any required degree of temperature; this room has an iron floor, through which heat rises to warm the air of the room; and over head are poles or bars on which the hanks of flax are hung.

The material being washed, bleached, and dried, we next follow it to some of the inner buildings of the factory, where it gradually assumes the form of woven cloth. All which precedes the actual weaving is effected in one large apartment; and a remarkable apartment this is, both in reference to its general appearance and to the nature of the processes carried on therein. Most persons have a general idea of the nature of woven fabrics, of the long threads, or 'warp,' the short threads, or 'weft,' and the manner in which they mutually interlace. But the preparation of the weft and warp involves a few details not much known beyond the manufacturing districts.

First, for the weft threads. These are used in the shuttle, the movements of which to and fro in the act of weaving form the web. Each shuttle contains a little pivot or axle called a 'quill,' loaded with the weft-yarn; and three or four machines of an ingenious kind are at work in the 'winding-room,' supplying these quills with yarn. In the old-fashioned process of hand-weaving the quills are filled by women or children, who use a humble-wheel to wind the yarn on them. The quill-machines, however, each of which is attended by one woman, have a considerable number of quills ranged in a row, and made to rotate rapidly. In the act of rotation the quills draw off yarn gradually from reels on which it had previously been wound; and the women renew the quills and the reels as fast as the one are filled and the other emptied. A comparison between this operation and that of winding on quills separately, as we saw it being done by a little boy for the hand-loom weavers in another part of the factory, illustrates strikingly the saving of time effected by the former. The little quills in the quill-machine, rapidly revolving and feeding themselves with yarn, require but little care from the attendant, who can manage a whole machine full of them at one time.

The yarns for the 'warp' are prepared for the weaver with more difficulty. At the entrance-end of the 'winding-room' we see four machines for winding the yarn on bobbins. The skeins of yarn are put on a kind of skeleton wheels about two feet in diameter, from whence they are transferred to bobbins about five or six inches long. Here everything seems to be in motion; the wheels or reels on which the skeins are placed, the bobbins for the reception of the yarn, and cylinders or rollers for pressing the yarn close to the surface of the bobbins.

But the most remarkable stage in the proceedings is the next following, of which we have endeavoured to give a sketch in the annexed cut. It is only by closely following the career of a thread through the machine that we can see what processes it undergoes. In the first place, nearly nine hundred bobbins are arranged in an upright frame, so that each one can give off its thread without entanglement with the others. The nine hundred yarns, unwinding from the bobbins, pass through nine hundred little eyes or loops, and then between an equal number of meshes or reeds, to bring all into parallel order. Then the whole nine hundred, forming a flat band or layer five or six feet wide, pass between two revolving rollers, the lowermost of which dips into a trough full of paste, by which every thread becomes soaked therewith. Then they pass between horse-hair brushes, one over and one under, each of which is as long as the whole width of the row of threads, and two or three inches wide. The effect of

this brushing is to equalize the paste on every separate yarn, very much more equably than it could be effected by a hand-brush. Then, without disturbing the parallel arrangement of the yarns, they are made to pass over a steam-heated copper box or cylinder, whereby the paste is partially dried; and immediately afterwards over a steam-heated iron box, when the drying is completed. The dried yarns next pass through the weaver's 'harness,' that is, small loops in a row of strings; and are lastly wound on the weaver's beam, ready to be put into the loom.

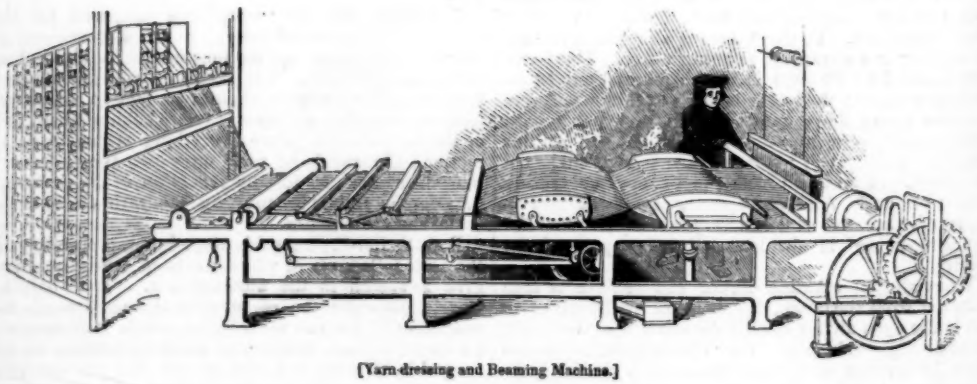
Nothing can exceed the regularity and order of this series of processes. The whole arrangement is about thirty feet long, that is, from the bobbin-frame to the warp-beam the yarn passes along that distance. The contents of all the eight or nine hundred bobbins are collected on one warp-beam, parallel, and in perfectly regular order. The yarn leaves the bobbins in a rough pliant state, and in a few seconds afterwards reachs the warp-beam stiffly starched and perfectly dry. The nine hundred bobbins are all revolving at once; so are the rollers; the paste-brushes have a brush-like kind of movement given to them, and the warp-beam is also revolving. Not only so, but the machine keeps its own accounts, for when a certain number of yards of yarn are wound on the beam, the machine rings a bell, and this gives the foreman an intimation which perhaps would not otherwise be so correctly given. There are in one room four of these large machines, four of the warp-winding machines, and three of those for quill-winding; all worked by shafts, wheels, and bands from an engine below.

The warp being filled by one sort of machine, and the shuttle-quills by another, we descend to a lower room, and witness the combination of the two sorts of yarn into cloth. Whoever has been to the Polytechnic Institution may have seen there a power-loom, and may have noticed the mode in which such complicated machines work. Forty of these, as we have before stated, are at work in the weaving-room of the factory, and may, from the noise which they create, give a foretaste of the giant establishments at Manchester. The machine throws its own shuttle, moves its own assemblage of warp-threads, drives up the weft-threads as fast as they are thrown, and winds the woven canvas on a roller. One woman is able to manage two power-looms, to supply warp and weft, mend broken threads, and remove the finished material.

Besides the power-looms, there are in the factory a considerable number of hand-looms also at work. The semi-scientific exhibitions in London have made these as well as the power-loom tolerably well known; and many a person has probably been surprised at the patience with which a man can sit for hours at a time throwing a shuttle alternately with his right hand and his left, moving a suspended bar alternately to and from him, and treading alternately on a lever with one or the other foot, and may have perhaps pondered how many movements of hand, arm, and foot must be made before a shilling can be earned.

One more process, and our sail-cloth is finished. It is taken to a 'receiving-room,' where it is examined, lumps and irregularities removed, measured, and weighed. In one part of the factory is a 'calendering' machine, through which all the canvas then passes. This machine consists mainly of one iron and two wooden rollers, which are made to approximate more or less closely together, according to the pressure intended to be given. The canvas is drawn between these rollers, and comes out flat, smooth, dense, and slightly glossed at the surface. It is then made up into compact parcels, called 'bolts,' in which form it passes into the hands of the sailmaker. A few particulars of this last-named occupation were given in the Supplement for June, 1841, and need not be repeated here. Sails are made at this factory, but for the most part the material leaves the establishment in the form of bolts, stamped and numbered.

This rough outline may perhaps have given a general idea of these two branches of manufacture; partially connected in some of their earlier stages, and closely connected in respect of their united importance to shipping.



[Yarn-dressing and Beaming Machine.]